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Master of Business Administration,
City University of Hong Kong

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Research Paper 2013-2014

Research Topic:

The Study on Operational Risk of
Chinese Commercial Bank

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Instructor: Dr. ZHU Rui

Date of Submission: 21-06-2013
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Chapter 1 Introduction

1.1 Background

In order to mitigate the severe risk for banks, the Basel Committee on Banking Supervision (BCBS) carried out a round of deliberations in 1988, and made a set of agreements on banks’ minimum capital requirement. Since the meeting was held in Basel, Switzerland, the protocol was also known as the 1988 Basel Accord, or Basel I. Basel I was first enforced by law in 1992 in the G10 countries, and it required banks with international presence to hold a minimum capital equal to 8% of the risk-weighted assets. The specified rate was thought to be adequacy enough for any level’s credit risk weights varying from 0 up to 100%.

Basel I was the first international protocol using risk to define Capital Adequacy Ratio (CAR). With the implementation of Basel I, risk management level had been enhanced greatly in the international banks. However, in late 1990s, the situation had changed as financial conglomerates, financial innovation and risk management developing. Moreover, CAR calculated under Basel I had been proved to be inadequate to withstand the potential market risk. Therefore, a more comprehensive set of guidelines were needed at that time.

In 1999, BCBS began to modify Basel I, and a series of revised protocols were published in 2004, which was known as Basel II. Basel II aimed to establish international standards for banking regulators to control the capital amount needed to guard against potential risks. Besides credit risk and market risk, operational risk was first introduced into the international accord. As defined in Basel II, operational risk was the risk of loss resulting from inadequate or failed internal processes, people and systems, or from external events. The identification and measurement of operational risk
were also stated, which will be explained elaborately in the following chapters.

Since the 1990s, globalization and deregulation in financial markets, combined with increased sophistication in financial technology, have introduced more complexities into the activities of banks and their risk profiles. Operational risks have attracted more and more attention in the banking industry. Including fraud, system failure, employees careless, etc. incorrect operations have caused severe losses in recent years. Founded in 1762, Barings Bank, as the oldest merchant bank in London, collapsed suddenly in 1995. The collapse was thought to be due to the unauthorized individual operation, lack of internal auditing and deficient risk management practices. Also in 1995, just seven months after the Barings’ collapse, Daiwa Bank was experienced a $1.1 billion loss just due to one trader’s illegal acts. Seven years later, in 2002, Allied Irish Banks (AIB) announced a $ 690 million’s loss at its subsidiary All First, Baltimore USA. The case was described as the largest bank fraud in the USA, and was caused by the fraudulent trading by one of their traders. Table 1.1 is a brief summary of operational-loss events collected from published media such as Sina.com, Baidu.com, People.com, and Xinhua.com.

The financial situation is always changing. Nowadays, the finance industry is becoming more and more globalized; the finance products are getting much complex and diversifying; computers are used excessively in the banking industry. A small mistake in the daily operation may cause a severe loss. The increase in the sophistication and complexity of banking practices has raised great concern on the operational risk management.
Table 1.1 Significant Operational Loss Cases

<table>
<thead>
<tr>
<th>Time</th>
<th>Bank</th>
<th>Losses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>Baring Bank, UK</td>
<td>Collapse due to a trader’s unauthorized operation, involved a $1.4 billion loss</td>
</tr>
<tr>
<td>1995</td>
<td>Daiwa Bank, NYC branch</td>
<td>A $1.1 billion loss due to a trader’s illegal operation</td>
</tr>
<tr>
<td>1997</td>
<td>National Westminster Bank, UK</td>
<td>A loss of £90 million due to mispricing of options by traders</td>
</tr>
<tr>
<td>2002</td>
<td>AIB, Ireland</td>
<td>$690 million was lost, caused by fraud</td>
</tr>
<tr>
<td>2003</td>
<td>Banco Intercontinental, Dominican Republic</td>
<td>Collapse due to fraud, involved a loss of $2.2 billion</td>
</tr>
<tr>
<td>2008</td>
<td>Société Générale, France</td>
<td>Totally lost $7.2 billion due to a trader’s fraud</td>
</tr>
<tr>
<td>2011</td>
<td>UBS, Swiss</td>
<td>Lost $2.3 billion due to a trader’s unauthorized operation</td>
</tr>
</tbody>
</table>

Source: 1) http://finance.sina.com.cn/g/20040625/1841834829.shtml  
3) http://financial.yingkelawyer.com/2011/05/16/98.html  
4) http://baike.baidu.com/view/1210907.htm  
5) http://www.people.com.cn/GB/historic/0926/4849.html  
6) http://caii.yibinu.cn/jrsx/content/xgal/chap05-02.htm  
9) http://finance.sina.com.cn/focus/xingyebian/  

In China, operational risk is also a severe problem. Although the reform in Chinese commercial banks has made some achievements, the existing problems cannot be negligible, mainly including excessive non-performing assets, bad debts, low CAR, lack of internal auditing and risk management measurements. All these problems reveal a potential threat in the Chinese banking industry, which may lead to a crisis if treated improperly. Three presidents of Bank of China (BOC) Kaiping branch totally stole 3.1 billion Yuan in 10 years during 1992 to 2001. During 1990 to 2003, bank staff in Industrial and Commercial Bank of China (ICBC) Nanhai branch fraud loan of total 7.4 billion Yuan,
colluding with external people. Currently, operational risk measurements remain on qualitative level; quantitative management is still undeveloped. A mature system to measure and control the operational risk is necessary in banking system.

To measure the operational risk, three methods are presented in the Basel II, which are Basic Indicator Approaches, Standardized Approach and Advanced Measurement Approach (AMA). In detail, AMA approach can be divided into three methods: Internal Measurement Approach, Loss Distribution Approach and Extreme Value Theory. Basel II recommends international banks to use the AMA approach. According to the bank’s actual situation, different methods can be chosen and applied by the bank itself. Compared with the credit risk and market risk, there are few models and tools to measure and control the operational risk. Besides that, banks usually prefer to conceal the loss instead of announcing it when there’s an operational loss occurred. Exact loss data are never published. In addition to choosing a proper research model, data collecting is another difficulty in the quantitative study of operational risks.

1.2 Objectives of This Research

Advanced Measurement Approach is the main focus of theoretical research and industry application, which includes Internal Measurement Approach (IMA), Loss Distribution Approach (LDA) and Extreme Value Theory (EVT). The disadvantage of IMA is that IMA is based on an important assumption: the relationship between the expected loss and unexpected loss of the bank has to be a stable linear; while for the EVT, it has not been put into practice because of lacking a great loss data. LDA can be implemented on the basis of external and internal data. To estimate the operating losses, loss frequency distribution and severity distribution should be calculated respectively. After that, Monte Carlo Simulation is adopted to determine the specific distribution of the overall loss, and then corresponding operational risk capital has been achieved in theory. Therefore, it is of theoretical and
practical significance to pitch on LDA for the study of the operational risk on Chinese commercial bank.

LDA has wider practical advantages: the risk sensitivity is be improved owing to the internal data of banks; lines of business and event types are defined by the banks, which reflect the bank’s business characteristics better than Basic Indicator Approach and Standardized Approach; based on bank’s historical loss data and focused in the distribution model, LDA builds the objective and statistically valid way to mirror the specific risk characteristics of the target bank. From the research by office of the Comptroller of the Currency, 58.33% of the financial institutions have applied LDA for measuring operational risk. In this paper, through the LDA metric model methodology and parameter estimation method research, more accurate funded principal can be estimated and bank's operational risk management will be boost.

1.3 Thesis Outline

The first chapter introduces the background of this research. The thesis structure and purpose are contained in this part. The significance and my contribution are also presented in chapter one.

Chapter 2 reviewed the previous study in the operational risk field. A literature review is written to summarize the previous research methods and data handling model. What’s more, a comparison and analysis among the previous methods are conducted.

The next, we will explain the definition and classification of operational risk, and describe the operational risk’s measurement methods. At the meantime, quantitative methods of operational risk - Basic Indicator Approach, the Standard Approach, and the Advanced Measurement Approach should be introduced and discussed.
The fourth chapter is the core part of the paper. In this part, we apply loss distribution approach in the operational risk measurement and management, discuss some distribution models for loss frequency distribution and loss severity distribution, and learn how to calculate the aggregate loss distribution. After that, we also conduct some related research for the lack of loss data.

On the basis of chapter four, two Chinese commercial banks are analyzed in chapter 5. For the China Construction Bank, the online banking fraud is focused to show the operational losses. Data are treated with the help of Matlab®, which is a kind of state-of-the-art software. The statistical model goodness of fit is applied to acquire the loss frequency probability distribution and loss severity probability distribution. Then, correlating the loss data we have gathered, we will calculate the aggregate loss distribution and estimate the bank’s expected loss amount. In the other case, the whole situation in Agriculture Bank of China is studied. Instead of focusing on a single business line, a cooperate-level study is performed. The same model will be used to deal with the data. Both results in the two cases shown that the mathematic model can get an acceptable prediction on the capital required to cover the operational risk.

In the last chapter, a brief summary of this research work is concluded. Further study on this topic is discussed at the same time. Personal benefits are also presented in this chapter.

Chapter 2 Literature Review

2.1 Operational Risk Approaches Review

For a long period, operational risk was thought to be qualitative only, and hard to be analyzed quantitatively. Commercial banks can only use Operation Manual or Risk List to control their daily
operations. In 1990s, people began to analyze the operational loss cases quantitatively.

Wilson (1995) used the concept of Value at Risk (VAR) to measure the operational risk, which was widely used concept in measuring credit risk and market risk. To carry out the calculation, the bank should establish its own database to record the operational losses both internal and external. The loss distribution can be observed based on the data, the VAR under a certain confidence level could be calculated. Based on the results, both quantitative and qualitative analysis should be carried out to measure the operational risk losses. Georges (2001) used both the Loss Distribution Approach (LDA) and Internal Measure Approach (IMA) method to compute the capital change for operational risk. VAR is calculated to measure the operational risk. Both LDA and IMA methods were explained elaborately, including the required database, analysis methods, and results comparison. Although LDA and IMA are both bottom-up internal measurement models, they are apparently different with each other. Several methods are recommended to mapping LDA and IMA together. Frachot (2004) simplified the standard LDA model into a more general empirical formula. However, how to collect the exact data was still the most critical problem in applying the simplified LDA model. Since the exact loss data were difficult to collect, confidence intervals were used to correct and supplement the frequency and severity data of the operational loss. The comparison shown the confidence internal method can correct the incomplete data into a more optimized level, which can be used in the LDA model. Kabir Dutta (2006) used LDA model to analyze the operational loss data collected by BCBS in 2004. The total loss was influenced by several factors, including the loss frequency, loss severity, data collection method and so on. Several suggestions were recommended on how to choose a proper model scientifically and how to standardize the LDA modeling.

Compared with the foreign scholars’ research, the operational risk research is started relatively late in China. Shen and Ren (2002) combined the operational risk theory and mathematic model in Basel II with the actual operations in Chinese commercial banking industry. They focused on qualitative
analysis of mathematic model in different banks but they did not give specific computing process and required capital. Based on Basel II, Zhong (2004) studied the AMA method, both qualitatively and quantitatively. The difficulties in applying the AMA method were discussed. Besides measuring the operational loss, recommendations on preventing and control the risk were analyzed from several aspects, mainly including improving employee’s quality, establishing the risk management and control framework, strengthening the internal auditing. Pan and Yang (2005) summarized the operational losses in Chinese banking industry from the published medium, estimated the distribution of the frequency and amount. Monte Carlo model was applied to calculate the quantile statistic under a given confidence level. Although the database was collected from public medium, it provided a method for the Chinese banks to estimate and calculate their operational risks quantitatively. In their research, they treated the whole banking industry as an entirety. And the data used in their study were all collected form open media. So the results did not reflect the real situation in an individual bank. Besides, the data samples were relatively small, which may result a relatively large error during the simulation. The calculation result shown that the required capital to cover the operation risk was about 190 billion Yuan under a 99.9% confident level, which was far larger than that in the real operation. Zhang and Lu (2008) calculated the required capital to resist operational risk in Chinese banks, based on the Monte Carlo simulation. The result shown that 10.7 billion Yuan was required; this had far exceeded Chinese banks’ capacity. In their opinion, the effective management of operational risk was necessary. Luo (2009) explained the LDA and IMA model, analyzed the application status in several international organizations, and proposed some key points when applying the Advanced Measurement Approach in Chinese commercial banks.

In short, foreign scholars have established a complete theory frame of the risk management under the more and more complex business environment. Some well-developed international banks also conducted series of quantitative research to estimate and control the operational risks. Quantitative measures are proposed to guide and control their daily operations. However, in China, most research
remains on theory discussion and qualitative measures. Mature quantitative models are still under development.

2.2 Loss Data Review

Mark Lawrence (2000), ANZ Bank’s chief risk officer, provided some suggestions for the banks to estimate the operational risk if the internal loss data is not adequate. Reynold and Syer (2003) applied a nonparametric approach to calculate the operational loss severity. A firm with six-year internal operational loss data was used as the hypothetical sample. Total 293 observations were recorded, ranging from 43 to 64 observations per year, with an average loss of $75700 to $ 117900. Based on the above data, the operational loss severity every time could be observed by repeating a large number of times in the simulation. For each year, the internal operational loss severity was the sum of loss severity in each simulation. The distribution of total operational losses is aggregated quantity of loss events yearly in accordance with the resulting empirical distribution. Wang (2008) suggested that database should be built by the Chinese commercial banks. To estimate the operational risk, no matter which model is used, a high quality data is the most important thing. In order to build an advanced management system, the banks should collect and record all the operational loss data; each department should do the same thing as the whole company. The industry’s loss data should also be recorded as supplementation.

In my study, the focus is on calculating of the total amount of capital required to cover the operational risks for Chinese commercial banks through loss distribution approach (LDA). China Construction Bank and Agriculture Bank of China are the two representatives of Chinese commercial banks to experience detailed calculation procedures. According to the LDA, the distribution frequency and severity of the operational loss events should be presented. The internal and external data of operational risks are the essential inputs. Therefore, the most significant point in my project is
that I collect the data of the two banks above by myself. I have gathered online banking fraud losses happened in China Construction Bank from 2005 to the end of 2010 by its annual reports. For Agriculture Bank of China, annual reports, working paper and social media disclosure are the main three approaches of data gathering from 2000 to 2009 since the internal data is not sufficient. After that I implement Monte-Carlo model to do the simulation and get simulation results.

Chapter 3 Operational Risk Measurement

3.1 Definition of Operational Risk

There’s no standard definition for the operational risk, different organizations and financial experts have different understandings of operational risk. Generally, the operational risk is divided into a narrow definition and a broad definition academically. The broad one defines operational risk as all risks other than credit risk and market risk. For the narrow definition, the history is described as follows.

In 1993, the Global Derivatives Study Group defined operational risk as "the risk of loss due to imperfect control and system, human error or mismanagement." It defined operational risk from three aspects: staff, system and operational processes, and treated management as a decisive factor to prevent operational risk. In 1998, Bank for International Settlements (BIS) defined that human or technical error is one type of operational risk, instead of market risk or credit risk. Laycock (1998) defined operational risk from different aspects. He mentioned that operational risk was fluctuations in income or cash flow caused by the customer, the lack of internal control, system failure or uncontrollable events. The definition considered external customers and uncontrollable factors, which is reasonable. In 2003, the U.S. Securities and Exchange Commission defined the operational
risk losses as unidentified limited excessive performance, unauthorized personnel instability, and easy-access system. In 2004, the Basel Committee officially defined the operational risk as “the risk of loss resulting from inadequate or failed internal processes, people and systems, or from external events.” To minimize the operational risk capital requirements, the above definition includes legal risk, but excludes strategic and reputational risk.

3.2 Operational Risk Classification

In the New Basel Capital Accord (Basel II), Basel Committee on Banking Supervision (BCBS) divided the operational risk loss events into several types according to the loss type and business field.

3.2.1 Risk loss type classification

According to the different types of risk events, the operational risk loss events can be divided into seven sub-types, which are described as follows:

**Internal fraud** means those frauds involved the staff themselves. Typical forms include staff-participated fraud, misappropriation of assets, in violation of the law as well as bank regulations, misreporting positions, staff self-theft, internal transactions via staff’s own account. Typical categories include unauthorized activity, theft and fraud.

**External fraud** means that fraud involved a third-party, including misappropriation of assets, violations of the law, robbery, forgery, empty promises, hacking computer systems. Systems security, theft and fraud are included in this type.
Employment system and workplace safety, including compensation claims due to non-performance of the contract or not complying with the labor health and safety regulations, complaints against employees' health and safety requirements, organized strikes and customer discrimination. Employee relations, systems environment, and diversity and discrimination are the three categories for employment system and workplace safety risk type.

Customers, products and business operations mean that behaviors which are unable to meet a customer's specific needs intentional or unintentional. Typical performance includes credit default, abusing customer’s information, improper trading practices of the bank accounts, money-laundering and unauthorized product sales. In this kind of operational risk, the categories should be divided in five parts: 1) suitability, disclosure, and fiduciary, 2) improper business or market practices, 3) product flaws, 4) selection, sponsorship, and exposure, and 5) advisory activities.

Damage to physical assets are the events due to catastrophic events or other events that cause damage to or loss of tangible assets, such as terrorist acts, acts of sabotage, earthquakes, fires and flood. Disasters and other events are the two phenomena in this kind of operational risks.

Business interruption and system failure include computer hardware and software errors, communication failures, power interruptions, and aging equipment.

Execution, delivery and process management means those behaviors such as transaction failure, process management error, and partners, the seller's failure of cooperation. Typical forms include data entry errors, collateral management failures, incomplete legal documents, illegal entry into the customer account, non-client counter party operational errors and seller disputes. So categories in this risk event consist of 1) transaction capture, execution, and maintenance, 2) monitoring and
reporting, 3) customer intake and documentation, 4) customer/client account management, 5) trade counter parties, and 6) vendors and suppliers.

3.2.2 Classification by the business lines

Another classification of the operational risk proposed by Basel Committee is classified according to the nature of the business. The operational risk is divided into eight business lines, including:

**Corporate finance** contains mergers and acquisitions, stock underwriting, asset securitization, initial public offering of government bonds and high-yield bonds;

**Trading and sales** include fixed income securities, equity, commodity futures, credit products, free positions in securities, leasing and redemption, brokerage, debt;

**Retail banking** consists of deposit and loan business, including retail, private deposit and loan business, trust management, investment advice;

**Commercial banks** comprise project finance, real estate, export finance, transaction financing, debt collection, leasing, guarantees, and loans;

**Payment and settlement** is made up with payment, transfer, liquidation;

**Agency services** cover contracts, deposit receipts, securities lending, issuance and payment of agency;

**Asset management**, including discretionary fund management and discretionary fund management;
Retail brokerage contains retail brokerage execution and other services.

3.3 Operational Risk Quantitative Analysis Method

The New Basel Capital Accord (Basel II) offers banks a different approach to estimate their exposure to operational risk. According to their specific situation, banks can choose between three main approaches: the Basic Indicator Approach (BIA), the Standardized Approach (SA) and the Advanced Measurement Approach (AMA). The basic frame of each approach will be introduced as follows:

3.3.1 Basic Indicator Approach

The Basic Indicator Approach (BIA) is the simplest one in estimating the operational risk. When using the BIA method, banks should hold a certain capital which is equal to a fixed percentage of average positive annual gross income over the previous three years. Figures for any year that the annual gross income is negative or zero should be excluded from both the numerator and denominator when calculating the average. The fixed percentage α is typically 15 percent of annual gross income, which is decided by the BCBS.

$$K_{BIA} = \left[ \frac{\sum_{i=1}^{n} GI_i \times \alpha}{n} \right]$$

(3.1)

Where: $n$ is the number of years with a positive annual gross income

$GI_i$ is the annual gross income in ith year

$\alpha$ the fixed percentage, decided by BCBS, usually 15%, representing for the whole industry’s management level.
BIA is simple in theory and operation. Given the gross income in the previous three years, the required holding capital can be calculated. However, two main drawbacks exist in the BIA method, lacking of standard and low sensitivity of risk. No matter which type of risks, the same percentage is applied. The BIA method is only recommended for banks without significant international operations.

3.3.2 Standardized Approach

The Standardized Approach (SA) divided a bank’s activities into 8 business lines: corporate finance, trading and sales, retail banking, commercial banking, payment and settlement, agency services, asset management, and retail brokerage. Each business line has a corresponding risk factor. To calculate the required capital for operational risk, first multiply the risk factor with the gross income for each business line, and then sum up the 8 business line’s result. The formula can be written as follows:

$$K_{SI} = \sum_{i=1}^{8} (G_{i} \times \beta)$$  \hspace{1cm} (3.2)

Where: \( G_{i} \) is the average gross income for each line in the previous three years

\( \beta \) is the risk factor, which is a fixed percentage decided by BSBC

SA method divides a bank’s activities into 8 different lines, and proposes a different risk factor for each business line. It reflects the risk characteristics in each different business line, and enables banks to know the operational risk better. However, the calculated capital by SA method cannot be connected with the actual loss data directly, and the result is not sensitive enough with the actual operational risk.
SA method and BIA method are both up-bottom methods, which only focus on the total target. The required capital is calculated at a macro level, details of the actual working procedures are not considered. The data collection is easy, and the calculation is simple, while the result is less reliable. There are several up-bottom models, including Operating Leverage Models, CAPM, BIA and SA model.

Compared with the up-bottom method, bottom-up method is based on each different business department. The total required capital can be decomposed into several subsidies in the different business line. The total capital for the risk can be derived by summing up all the subsidies.

Bottom-up method based on the internal management of a bank’s operational risk management. Compared with the up-bottom method, the bottom-up method is more accurate, more sensitive and cost saving. In fact, to report the loss data and monitor the capital requires calculating the risk in each business line one by one, and summing up the results. The AMA method in Basel II is actually a bottom-up method.

3.3.3 Advanced Measurement Approach

The Advanced Measurement Approach (AMA) applies statistic method to simulate and build up the distribution of the risk losses. The operational risk and the required capital are decided by the risk distribution. Based on the loss severity and loss frequency, simulations and analysis are carried out in the statistic model. The most possible risk can be obtained. The basic procedures are as follows:

(1) Group the loss type and loss field. For example, a loss can be described as hardware failure in the payment and settlement. Suppose the number of loss type is M, the number of loss field is N, the total group number is M x N;
(2) Build up the frequency distribution model of the loss type in each loss field. Find the loss frequency distribution and the respect severity;

(3) Use the loss data in the past to estimate the reference number in the above distribution; Decide the loss distribution in the above business line;

(4) Use statistical analysis and simulation experiment to obtain the most possible operational risk and the risk loss.

Currently, there are five models in the AMA method, which are Internal Measure Approach (IMA), Loss Distribution Approach (LDA), Scorecard method, Extreme Value method, Bayesian Networks method etc.

The Internal Measure Approach (IMA) assumes that there's a fixed relationship between the expected loss and unexpected loss, which enables banks to estimate the total risk loss based the expected loss. When applying IMA method, the real loss data in a bank can be used, which can reflect the real risk faced by the bank more accurately. However, the transferring factor is decided by the external supervision organization, the bank scale and management characteristics cannot be considered perfectly. By the way, IMA assumes that no matter which business line, there exists a fixed relationship between the expected loss and unexpected loss, which is a major drawback in applying the IMA method, especially when the loss data is not enough.

Loss Distribution Approach (LDA) combines the internal and external loss data when establishing the distribution model of loss frequency and severity. Using Monte Carlo simulation, the data is analyzed, and the total loss distribution will be built up. LDA uses the bank’s internal loss data, which has a high sensitivity to the operational risk. The business line type and loss type are decided
by the bank itself, which can reflect the bank's business characteristics better. The calculated capital requirement is much more accurate, since all the data is based on the bank’s loss data in the past. However, a large database is required to carry out the LDA method.

Scorecard method uses a number of indicators to detect, measure, analyze and allocate the required capital calculated by other methods. The scorecard method is a forward-looking approach; it is a self-assessment of the bank operational risk, and focuses on qualitative analysis. But the scorecard method is based on subjective judgment; indicators and weights are determined by experienced experts, making it a strong subjectivity, low risk measurement stability.

Extreme value method is used to study the loss distribution tail in the operating risk. It can estimate the loss beyond the sample data. Based on the sample data, the changing nature of the extreme value can be obtained overall. Extreme value method can determine the expectations of operational risk losses; analyze the distribution tail data without assuming the loss distribution. However the extreme value theory is still under research, the analysis based on extreme value theory depends on the distribution of extreme losses characteristics, while completely ignoring the moderate and low loss characteristics of the data.

Bayesian network method is a combination of qualitative and quantitative analysis. Integrating the historical data, it can get its own database. The reasons of the pass losses are used to predict the future operational risk loss events. Bayesian network method bases on artificial neural network, and is a complex set of expert systems. It describes the factors' correlation from the point of the probability of occurrence of operational risk loss events, which is able to solve the problem of inconsistencies in the data. Bayesian network learning and training is a long-term process and requires a lot of historical data. The Bayesian network is widely used in mechanical, electronic fault diagnosis as well as forest pest and disease prevention; however in the commercial banking industry,
the application is still in the theoretical research stage. A brief compassion of the above five method
is summarized in the following table 3.1.

<table>
<thead>
<tr>
<th>Method</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMA</td>
<td>easy to apply, simply</td>
<td>1. bank scale and management characteristics are ignored.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. relationship between expected loss and unexpected loss is assumed to be fixed.</td>
</tr>
<tr>
<td>LDA</td>
<td>1. high sensitivity</td>
<td>1. excessive database needed</td>
</tr>
<tr>
<td></td>
<td>2. autonomy</td>
<td>2. not looking-forward</td>
</tr>
<tr>
<td></td>
<td>3. directly estimate the unexpected loss</td>
<td></td>
</tr>
<tr>
<td>Scorecard method</td>
<td>1. looking-forward</td>
<td>1. excessive database needed</td>
</tr>
<tr>
<td></td>
<td>2. self-evaluative</td>
<td>2. subjective, and unstable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. lack of quantitative analysis</td>
</tr>
<tr>
<td>Extreme value</td>
<td>1. able to estimate the expected loss</td>
<td>still under research, immature</td>
</tr>
<tr>
<td>method</td>
<td>2. able to estimate the loss beyond the sample data</td>
<td></td>
</tr>
<tr>
<td>Bayesian network</td>
<td>1. able to deal with inconsistent data</td>
<td></td>
</tr>
<tr>
<td>method</td>
<td>2. highly reliable after improvement</td>
<td>1. excessive database needed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. long-training period</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. still under research</td>
</tr>
</tbody>
</table>

To conclude, BIA and SA methods are easy to calculate; however, the sensitivity to the operational
risk is relatively low. Only small banks are suitable to use the BIA and SA method. For international
banks, AMA is recommended by BCBS. Several methods under the AMA frame are compared and
the result is summarized in table 3.1. Scorecard method, Extreme value method and Bayesian
network method are still under research; While IMA is too simply, and not accurate. Based on the
Chinese commercial bank’s real situation, LDA method is used in this study.
Chapter 4 Application of Loss Distribution Approach

4.1 Introduction

LDA is on the assumption that operational risk loss event’s loss frequency and loss severity have been given. There are 56 types of loss in the matrix composed of the 8 business lines /7 loss events, we calculate every case’s loss frequency distribution and severity distribution, and then by the convolution the aggregate loss distribution is obtained. At last, a bank’s operational risk loss events loss distribution is equal to the 56 types’ loss distribution. In a certain period of time (usually a year), as well as a certain confidence level (99.9%), we can calculate each case’s VaR, and then the total risk capital shall be calculated as follows:

\[ K_{LDA} = \sum_{j=1}^{8} \sum_{k=1}^{7} VaR_{jk} \]  \hspace{1cm} (4.1)

By a certain confidence level (99.9%) the operational risk loss distribution function’s VaR directly means the maximum possible loss. In this case, Venture capital determined by the VaR can cover operational risk losses beyond the 0.1% unexpected - extreme risk,

Assuming random variables X1, X2, ... are independent and identically distributed, the distribution function is:

\[ F(x) = P\{X_i \leq x\} \leq \alpha \]  \hspace{1cm} (4.2)

*Where: \( \alpha \) is the confidence level, usually 95% < \( \alpha \) < 1.*

So, if \( F(x) \) has been determined, for a constant confidence level, we can estimate it’s VaR as follows:
\[ \text{VaR}_q = F^{-1}(q) \] (4.3)

In order to calculate conveniently, the total risk capital is the same with the sum of each type, for the purpose in this paper we consider all the loss is irrelevant.

LDA is an actuarial model. The operating loss event frequency distribution and severity distribution which represents the economic impact after loss event occurred are two important aspects of in LDA. The next we will discuss loss frequency distribution and loss severity distribution.

4.2 Mathematical Model

4.2.1 Loss Frequency Distribution

The frequency of loss events can be counted by hours, days, weeks, months, years, the selection of units is no special provision, people usually choose months as the unit for event occurred times, in this way, statistics events have the accumulation of a certain span of time, and the span is not too long, so the results reaction the frequency of operational risk loss events precisely.

There are some common discrete random distributions and continuous random distributions to describe the frequency of loss events, such as Binomial distribution, Poisson distribution, Normal distribution and Logarithmic Normal distribution.

Binomial distribution is also called Bernoulli experiment, in this distribution each success with probability \( p \) and failed with probability \( q \), \( q \) is equal to \( 1-p \). The probability of getting exactly \( k \) successes in \( n \) trials is given by the probability mass function:
\[ P(X = k) = C_n^k p^k q^{n-k} \]  

(4.4)

If \( X \) is a binomially distributed random variable, then the expected value of \( X \) is \( np \) and the variance is \( npq \).

Poisson distribution expresses the probability of a given number of events occurring in a fixed interval of time or space if these events occur with a known average rate and independently of the time since the last event. In a fixed interval of time, if the average rate is \( \lambda \), so the probability mass function of \( X \) is given by:

\[ P(X = k) = \frac{e^{-\lambda} \lambda^k}{k!}, \quad k = 0, 1, 2, ... \]  

(4.5)

If \( X \) is a binomially distributed random variable, \( \lambda \) is equal to the expected value of \( X \) and also to its variance, figure 4.1 is the probability distribution graph of Poisson distribution(for example, \( \lambda = 10 \)).

**Figure 4.1 Probability distribution graph of Poisson distribution**
The Normal distribution is a continuous probability distribution, defined by the formula

$$f(x) = \frac{1}{\sqrt{2\pi \sigma}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$  \hspace{1cm} (4.6)$$

The parameter \(\mu\) in this formula is the expectation of the distribution and \(\sigma^2\) is variance, figure 4.2 is the probability distribution graph of Normal distribution (for example, \(\mu=40, \ \sigma^2=36\)).

**Figure 4.2 Probability distribution graph of Normal distribution**

Logarithmic normal distribution is a continuous probability distribution of a random variable whose logarithm is normally distributed. The probability density function of a Logarithmic normal distribution is:

$$f(x) = \frac{1}{\sqrt{2\pi \sigma}x} e^{-\frac{(\ln x - \mu)^2}{2\sigma^2}} \hspace{1cm} x > 0$$  \hspace{1cm} (4.7)$$

By Maximum Likelihood Estimation (MLE), we get:
\[
\hat{\mu} = \frac{1}{n} \sum_{j=1}^{n} \log x_j \\
\hat{\sigma} = \frac{1}{n} \sum_{j=1}^{n} (\log x_j - \hat{\mu})
\] (4.8)

So, the distribution’s expectation is \( e^\frac{\mu + \sigma^2}{2} \), and the variance is \( (e^{\sigma^2} - 1)e^{2\mu + \sigma^2} \).

Figure 4.3 is the probability distribution graph of Logarithmic Normal distribution(for example, \( \mu=7, \sigma^2=4 \)).

**Figure 4.3 Probability distribution graph of Logarithmic Normal distribution**

The four probability distributions are common probability distributions to the loss of operational risk events. Poisson and binomial parameters can be obtained by maximum likelihood estimation, normal and lognormal distribution by curve fitting.
4.2.2 Loss of Severity Distribution

The loss severity distribution of operational risk means size of event loss. It provides information about the extent of the loss in the operational risk loss events. We commonly use the exponential distribution, Weibull distribution, Normal distribution and lognormal distribution to evaluate loss severity distribution. Normal distribution and lognormal distribution has been introduced in the previous section, this section only describes the exponential distribution and Weibull distribution.

The probability density function of an exponential distribution is

$$f(x) = \begin{cases} \lambda e^{-\lambda x} & x \geq 0 \\ 0 & x < 0 \end{cases}$$  \hspace{1cm} (4.9)

The expected value of an exponentially distributed random variable $X$ is $1/\lambda$, the variance is $1/\lambda^2$.

Figure 4.4 is the probability distribution graph of exponentially distribution (for example, $\lambda=0.2$).

**Figure 4.4 Probability distribution graph of exponentially distribution**
4.3 Data Requirements

The LDA method is for bank to estimate its loss distribution based on the collection of operational risk loss data. The loss data of the New Basel Capital Accord should be divided into the internal data and external data. Internal data is generated by the Bank's operational risk loss data, while external data is generated by other banks operational risk loss data, publicly available data and number of collections of the whole financial industry.

Bank's track record of internal loss event is the main part to develop reliable operational risk measurement system. Internal loss data is to build a bridge between the bank's risk assessment and the actual loss. Risk estimates as well as the empirical analysis can be used as the means of to verify bank risk measurement system's input and output variables.

However, external database generally record the extreme losses that the highest part of the amount of the loss and not yet by a rigorous statistical processing. The loss estimated through such a comprehensive between internal data and external data is to be biased in favor of high losses, which calculated the operational risk capital requirements will seriously overestimated. In addition, the use of external data measurement with internal data will bring a range of questions, such as different quality between internal and external data, expansion the scale of risk capital and the lack of compatibility. Therefore, we must analyze the application environment before using external data for the supplementary of data base.
Chapter 5 Test and Results

5.1 Introduction

In previous chapter, the process of LDA to calculate the capital which is able to cover the operational risks has been demonstrated. In the following Figure 5.1, the detailed calculation procedures are described in a format of flow diagram.

Figure 5.1 Operation Risk Loss Capital by LDA Calculation
To carry out the operational risk losses calculation, data source is the most important component. This mainly depends on the bank itself. The banks have responsibility to disclosure the loss events publicly. In this paper, the internal loss data in a certain bank will be collected based on the database of the target bank, such as annual reports, working paper, etc. After the internal data is collected, some criteria will be applied to roughly check whether the data is sufficient, such as whether the data is enough, whether the data distribution is uniform, etc. The next step is to carry out a scenario analysis. Based on this, the distribution frequency and severity of the operational loss events could be established and improved. Monte-Carlo model would be employed to do the simulation. VAR will be calculated based on the simulation results. The total capital required to cover the operational risk could be derived then. Some adjustment would be added to make the calculation finer.

In the following sections, case analysis on the operational risk in the Chinese commercial banks will be conducted by the LDA method. Calculation of the capital required to cover the operational risks for Chinese commercial banks will be presented. The situation in China Construction Bank and Agriculture Bank of China, which are two of the “Big Four” banks, will be analyzed in details.

5.2 Analysis of operational risk data of China Construction Bank

5.2.1 Loss Data and Descriptive Statistics

Along with the rapid development in the Internet bank, the online fraud phenomena received more and more attention, especially in the “big four” Chinese national commercial banks. Among the “big four”, China Construction Bank (CCB) starts to collect and record the operational loss events since 2005, which is one of the pioneers in China. Besides, all the factors of the loss events, including the time, loss value, etc. are recorded in their annual report, which can provide a complete data system for this study.
During my communication with the staff in CCB, they expressed that they are also very eager to establish a mature system to manage the operational risk. The data used in this study are mostly provided by the CCB staff and CCB’s annual report. In detail, for example, after I get the annual report, I will see the content table first. The focus should be on the risk management section. Carefully read this section, and extract the useful information on the operational risk management. The basic searching flow can be summarized as: Notes to financial statements → Risk management → Operational risk → Online fraud.

According to statistics of internal data, from 2005 to the end of 2010, China Construction Bank has happened online banking fraud events 6140 times totally. Among these events, 2469 cases have been confirmed the total losses. The analysis of online banking fraud events is on the basis of the amount of confirmed losses. Considering that during October 2005 to December 2007, online banking fraud incident number is dramatically less than the year after 2008, and it has many accidental factors, this paper adopts the data of three years between January 2008 and December 2010. In this period, online banking fraud events happened 2342 times and it occupied 94.86% of all the data. From the amount of losses, the bank’s minimum loss is 0.1 Yuan, and the largest number is up to 759,600 Yuan, and average loss amount is about 20,000 Yuan. The loss frequency and loss amount of China Construction Bank online banking fraud events has been listed in table 5.1, and the histogram is shown in figure 5.2.
Table 5.1 Statistical Form of Loss Amount

<table>
<thead>
<tr>
<th>Loss Amount X(Yuan)</th>
<th>Loss Frequency (Times)</th>
</tr>
</thead>
<tbody>
<tr>
<td>X&lt;1,000</td>
<td>266</td>
</tr>
<tr>
<td>1,000≤X&lt;2,000</td>
<td>119</td>
</tr>
<tr>
<td>2,000≤X&lt;3,000</td>
<td>94</td>
</tr>
<tr>
<td>3,000≤X&lt;4,000</td>
<td>78</td>
</tr>
<tr>
<td>4,000≤X&lt;5,000</td>
<td>99</td>
</tr>
<tr>
<td>5,000≤X&lt;6,000</td>
<td>103</td>
</tr>
<tr>
<td>6,000≤X&lt;7,000</td>
<td>75</td>
</tr>
<tr>
<td>7,000≤X&lt;8,000</td>
<td>87</td>
</tr>
<tr>
<td>8,000≤X&lt;9,000</td>
<td>67</td>
</tr>
<tr>
<td>9,000≤X&lt;10,000</td>
<td>73</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>≥150,000</td>
<td>3</td>
</tr>
</tbody>
</table>

Figure 5.2 Histogram of Loss Amount

In order to show the calculation process more clearly, the statistics of online banking fraud incident frequency regard month as the unit, that is we use the amount of losses per month to test. The total of 36 months is from Jan 2008 to Dec 2010, and the histogram of loss times (in month) is revealed in figure 5.3.
5.2.2 Fitting Test of Loss Severity

The severity of the operational risk loss data generally correspond to normal distribution, exponential distribution, logarithmic normal distribution and Weibull distribution. According to the known data, assume that the data conform to a certain distribution. Then its parameters could be estimate through the calculation of distribution hypothesis. Therefore the sample’s distribution type should be obtained.

When using samples to estimate overall distribution, reliability is divided into different levels. Thus it’s necessary to conduct further check and confirm. General hypothesis test step is: carrying on the test of goodness of fit when significant factor is given. If the inspection result is less than setting level, in confidence level 1 - a, the samples results should be considered to estimate overall distribution. The significant factor often takes 0.05 ($\alpha = 0.05$) to ensure the high reliability.
Implement K-S inspection to goodness of fit of four kinds of distribution above respectively, only the exponential distribution test value is less than 0.05, so the online banking fraud loss severity distribution is in line with exponential distribution. The $\lambda = 8.772$, and figure 5.4 represents distribution fitting chart.

**Figure 5.4 Distribution Fitting Chart**

In conclusion, loss amount is subject to exponential distribution as follows:

$$f_{bud}(x) = \begin{cases} 0.114e^{-0.114x} & x > 0 \\ 0 & x \leq 0 \end{cases}$$

(5.1)

In addition that factors such as different period, various business, loss severity's distribution types and parameters that specific data subject to might be diverse. In this article, distribution analysis is only determined by the known samples.
5.2.3 Fitting Test of Loss Frequency

Operation risk loss frequency distribution should be commonly assorted Poisson distribution and geometric distribution, Weibull distribution, normal distribution and lognormal distribution. Conduct K-S inspection to goodness of fit of five kinds of distribution above respectively, the results show that Weibull distribution of K-S value is far less than the rest four kinds of distribution. Therefore, the loss of the frequency distribution complies with Weibull distribution and the fitting curve is displayed in figure 5.5 ($A=69.1$, $B=1.79$).

![Figure 5.5 Weibull Distribution and the Fitting Curve](image)

In conclusion, the Weibull distribution of frequency should be as follows:

$$f_{lfd}(x) = \frac{B}{A} \left( \frac{x}{A} \right)^{B-1} e^{- \left( \frac{x}{A} \right)^B} = 0.0259 \left( \frac{x}{69.1} \right)^{0.79} e^{- \left( \frac{x}{69.1} \right)^{0.79}}$$

(5.2)
5.2.4 Loss Distribution of Monte Carlo Simulation

Through formula (5.1) and formula (5.2), loss severity and frequency distribution of online banking fraud events would be calculated, and then the loss of data distribution can be obtained through simulation theory. The Monte Carlo method is one of common simulation methods which have been accepted widely. In this paper, simulating online banking fraud loss distribution by using the Monte Carlo Simulation method and its basic train of thought is as follows:

(1) Assuming that the online banking fraud loss severity \( A_i \) obeys the exponential distribution, loss frequency \( B_i \) is normal distribution, both are as input variables;

(2) Require overall loss distribution \( C_i \) as output variables;

(3) Randomly generated a sample I, make \( A_i \) obeys the exponential distribution, the \( B_i \) obeys normal distribution, then \( C_i = A_i \times B_i \)

(4) Repeat (3) process. When sampling is big enough, the overall loss distribution would be reached.

In general requirements, the Monte Carlo Simulation should proceed in more than 10,000 times. After 100,000 times of simulation in this paper, the overall loss distribution can be demonstrated in figure 5.6.
The overall loss distribution figure shows that it happens more probably for small loss event, the probability of event would be reduced along with the increase of loss amount, and the reduced speed is quite fast. Moreover, huge losses events (the amount loss is greater than 1 million) might also occur, but the probability is very low.

At the same time, when analyzing of data obtained by Monte Carlo Simulation, the overall loss distribution can be expected to: 289,970 Yuan and the standard deviation is: 170,290 Yuan. The loss in 100% percentile is 1,422,429 Yuan. In order to understand the distribution structure of loss distribution more intuitively, the distribution of the loss is presented in table 5.2 percentile order sheet.
Table 5.2 Percentile Loss Distribution

<table>
<thead>
<tr>
<th>Percentile (%)</th>
<th>Loss Amount X(Yuan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>263,690</td>
</tr>
<tr>
<td>60</td>
<td>309,217</td>
</tr>
<tr>
<td>70</td>
<td>361,975</td>
</tr>
<tr>
<td>80</td>
<td>427,031</td>
</tr>
<tr>
<td>90</td>
<td>523,329</td>
</tr>
<tr>
<td>99.9</td>
<td>1,158,548</td>
</tr>
<tr>
<td>100</td>
<td>1,422,429</td>
</tr>
</tbody>
</table>

5.2.5 Operational Risk Covering Capital Based on VAR Calculation

Obtaining operational risk loss distribution is not the final purpose, and we intend to exploit it to determine the proper capital covering operational risks of commercial banks. VAR is the difference between quantile loss value and loss expectation under a certain confidence level. The balance is capital required to resist the operational risks. According to Basel’s third proposal of consultation, this study has selected the whole year to be the loss interval and pitched on the confidence level (99.9%) which is the same as the credit risk and market risk confidence level to determine operational risk capital.

The unit of frequency distribution in this simulation is month, so to calculate operational risk capital in the whole year, there is great need to transform the unit. The relationship between annual VAR and monthly VaR would be as follows:

\[
VaR_{annual} = VaR_{month} \times \sqrt{12}
\]  

(5.3)

From table 5.2, through the point of 99.9% fractile 1,158,548 Yuan and expectation data 289,970 Yuan, expectation monthly VAR can be received, that is 868,578 Yuan. Afterwards generate the monthly VAR into the formula (5.3) annual VAR can be got to 3,008,842 Yuan. Therefore, to defend against online banking fraud operational risks loss events, China Construction Bank need to prepare
the 3 million Yuan of capital.

Assumes that the severity distribution of 56 business lines are accord with the same loss index distribution, loss frequency distributions are conform to normal distribution. Therefore, construction bank’s total venture capital reaches to 168 million Yuan under the condition of the confidence level of 99.9%.

To be sure, in the process of simulation, due to restricted by factors such as data, some problems need to be further discussed, such as assuming that loss of severity of different business lines and loss frequency distribution are in accordance with the same distribution. In fact, the severity and frequency of each type of distribution are quite different. Therefore, we put diverse business lines’ severity distributions into the same distribution (business lines’ frequency distributions lay in the same situation) since the data is limited. If there is enough data of diverse business lines and loss events, this paper will apply fitting method to analyze them respectively, thus the results will be more accurate and scientific.

5.3 Analysis of operational risk data of Agricultural Bank of China

In previous sections, we have described the operational risk loss frequency and loss severity distribution for a single business line and the calculation of the overall loss distribution. The mathematic model and simulation results are validated. In this section, the same theory will be applied to analyze the whole situation in a bank. Compared with Bank of China (BOC) and Industrial and Commercial Bank of China (ICBC), the data from Agricultural Bank of China are more comprehensive. The following part applied the statistic data of Agricultural Bank of China (ABC) during 2000 to 2009 to give another illustration.
The total number of loss data caused by operational risk during 2000 to 2009 is 286. We need to remove the events with the loss amount of 0, 1, and 1,479 million. The total number of operational risk loss events used in this case is 281. Matlab® is applied to fit analysis of the operational risk loss frequency and loss severity distribution. Table 5.3 shows Agricultural Bank of China’s operational risk loss frequency from 2000 to 2009, and its distribution histogram is shown in figure 5.7.

### Table 5.3 The loss frequency from 2000 to 2009

<table>
<thead>
<tr>
<th>Year</th>
<th>Frequency(times)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>20</td>
</tr>
<tr>
<td>2001</td>
<td>23</td>
</tr>
<tr>
<td>2002</td>
<td>25</td>
</tr>
<tr>
<td>2003</td>
<td>33</td>
</tr>
<tr>
<td>2004</td>
<td>47</td>
</tr>
<tr>
<td>2005</td>
<td>51</td>
</tr>
<tr>
<td>2006</td>
<td>34</td>
</tr>
<tr>
<td>2007</td>
<td>18</td>
</tr>
<tr>
<td>2008</td>
<td>15</td>
</tr>
<tr>
<td>2009</td>
<td>14</td>
</tr>
</tbody>
</table>

### Figure 5.7 Loss frequency distribution histogram from 2000 to 2009
According to the data histogram characteristics, we used the Poisson distribution and Weibull distribution to conduct operational risk loss frequency fitting. To intuitively describe operational risk’s loss frequency distribution, we present the loss frequency fitting figure. From figure 5.8, it can be easily find that loss frequency distribution trend is accord with Poisson curve. The results show that the operational risk loss frequency distribution fit Poisson distribution when $\lambda = 27.8842$.

**Figure 5.8 Poisson Distribution and the Fitting Curve**

![Figure 5.8 Poisson Distribution and the Fitting Curve](image)

Table 5.4 is the ABC’s loss severity from 2000 to 2009, and its distribution histogram as shown in Figure 5.9. The amount of operational risk loss varies widely, and the data’s distribution is the heavy-tailed distribution, which means high-frequency by low-loss and low-frequency by high-loss.
Table 5.4 The loss severity from 2000 to 2009

<table>
<thead>
<tr>
<th>Loss Amount X (Yuan)</th>
<th>Loss Frequency (Times)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5,000</td>
<td>245</td>
</tr>
<tr>
<td>5,000 ≤ X &lt; 10,000</td>
<td>10</td>
</tr>
<tr>
<td>10,000 ≤ X &lt; 15,000</td>
<td>4</td>
</tr>
<tr>
<td>15,000 ≤ X &lt; 20,000</td>
<td>6</td>
</tr>
<tr>
<td>20,000 ≤ X &lt; 25,000</td>
<td>2</td>
</tr>
<tr>
<td>25,000 ≤ X &lt; 30,000</td>
<td>2</td>
</tr>
<tr>
<td>30,000 ≤ X &lt; 35,000</td>
<td>5</td>
</tr>
<tr>
<td>35,000 ≤ X &lt; 40,000</td>
<td>3</td>
</tr>
<tr>
<td>45,000 ≤ X &lt; 60,000</td>
<td>0</td>
</tr>
<tr>
<td>60,000 ≤ X &lt; 65,000</td>
<td>1</td>
</tr>
<tr>
<td>65,000 ≤ X &lt; 70,000</td>
<td>0</td>
</tr>
<tr>
<td>70,000 ≤ X &lt; 75,000</td>
<td>1</td>
</tr>
<tr>
<td>75,000 ≤ X &lt; 80,000</td>
<td>0</td>
</tr>
<tr>
<td>80,000 ≤ X &lt; 85,000</td>
<td>1</td>
</tr>
<tr>
<td>85,000 ≤ X &lt; 105,000</td>
<td>0</td>
</tr>
<tr>
<td>≥ 105,000</td>
<td>1</td>
</tr>
</tbody>
</table>

Figure 5.9 Operational risk loss severity distribution histogram

Figure 5.10 shows the fitting curve in order to demonstrate the loss data for operational risk’s loss severity distribution visually. On the basis of the curve trend, the loss severity has obvious characteristics of the lognormal distribution. Thus we use Matlab® to fit the lognormal distribution, and fitting results is valid \( \mu = 4.9753, \sigma = 2.9631 \).
The next we use the operational risk loss frequency distribution and severity distribution function for Monte Carlo simulation, the simulation times is 100,000.

Specific steps are as follows:

(1) Generate a random sample in accordance with Poisson distribution which parameter $\lambda = 27.8842$, the length is 100,000;

(2) In each Poisson random sample, exploit the logarithmic normal distribution to calculate the amount of loss;

(3) Repeat step (2) 100,000 times, we can get the expected loss values.
Monte Carlo simulation results show that the maximum operational risk loss is 98.463 million Yuan, and the minimum is 286 Yuan, with an average loss of 13.894 million Yuan. The distribution of the loss is presented in table 5.5 percentile order sheet, and the overall loss distribution is shown in figure 5.11.

Table 5.5 Percentile Loss Distribution

<table>
<thead>
<tr>
<th>Percentile (%)</th>
<th>Loss Amount X(Yuan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>942,549</td>
</tr>
<tr>
<td>60</td>
<td>1,201,627</td>
</tr>
<tr>
<td>70</td>
<td>1,640,346</td>
</tr>
<tr>
<td>80</td>
<td>2,821,731</td>
</tr>
<tr>
<td>90</td>
<td>8,283,394</td>
</tr>
<tr>
<td>99.9</td>
<td>97,581,164</td>
</tr>
<tr>
<td>100</td>
<td>98,463,790</td>
</tr>
</tbody>
</table>

Figure 5.11 Overall Loss Distribution

In summary, the ABC’s operational risk data fitting and simulation shows that in the confidence level of 99.9, the VAR = 83.687 million. However, because the amount of data collected in the literature is very few, the simulation results of operational risk capital may be different with the actually fact.
Chapter 6 Conclusion

6.1 Project Conclusion

Operational risk is a common problem which plagued many large commercial banks in the world. Particularly the major international financial loss events caused by operational risks occurred one after another, more and more professionals have paid attention to operational risk.

In the thesis, we introduced the definition of operational risk, analyzed the causes and harm of risk, gave the definition and classification of operational risk. To expand our knowledge, we also found and read a lot of literatures, and made a comparison and analysis of these methods which based on the studies in the domestic and overseas.

To get an effective operational risk management, the first step is measuring the operational risk loss. While compare with market risk and credit risk, operational risk measurement is not mature, even that a lot of researches on operational risk are just in the theoretical stage. Combining with the actual situation of China's commercial banks and comparing to the advantages and disadvantages of the operational risk measurement methods, the paper pitches on LDA to measure the operational risk loss.

When utilizing LDA to analyze operational risk loss, the most critical step is the selection distribution model for loss frequency and loss severity. So we have introduced some common types of loss distribution, and have discussed how to use the Monte Carlo Simulation processing data. During processing data, we select some external data to support the research, and then we analyzed the problems which caused by using external data because of internal data is sorely lacking.
Based on CBC online banking fraud loss data and ABC loss data, we apply LDA to analyze the loss data, and gain the total operational risk loss by Monte Carlo Simulation under a certain confidence level of 99%.

**6.2 Future Work**

Due to the limited of capacity and time, the paper also has some insufficiencies to be studied and discussed in the future work and learning.

Firstly, we need to gather further data. In this study, we only get the Construction Bank online banking fraud data, the remaining 55 lines of business / types of loss have no data yet. While different loss data should have various types of distribution. Therefore, in the paper, using a group of business line / loss type to estimate the remaining 55 business lines / loss types is unscientific.

Secondly, the total operational risk loss has been estimated, but there is a certain distance based on estimated loss to indicate the actual operational risk. The next focus is the create risk model of loss through practice, eventually build a relatively complete commercial banks operating risk warning system.

Finally, the cumulative distribution function is a joint distribution. However, in this article, we assumed that loss frequency distribution and loss severity distribution are independent of each other. Then the probability of two events is equal to the cumulative distribution probability, but in fact they are not independent. Therefore, the research on cumulative distribution function is still need to be improved.
6.3 Personal Summary

During the past eight months, I have finished the MBA project with the advice of LI Bei, QIU Zhiyuan, and XU Yaohua, especially with the instruction of Dr. ZHU. Without the Dr. ZHU’s supervision and suggestions, it is impossible for me to complete this paper so effectively and efficiently. Such a research experience makes me benefit a lot.

The first and most important point should be the ability to apply the financial knowledge. I was majored in International Finance during my undergraduate study and very interested in finance, so I choose my MBA project in the financial field. Thought this project, I applied the financial knowledge and financial tool to collect and analyze the data. Mathematic model was established to analyze the distribution of loss frequency and loss intensity. Monte-Carlo model was used to simulate the operational loss situation. The simulation results were compared with the statistic data in the Chinese banking industry. The MBA project provides me a chance to connect the economic theory with the phenomena happened in the real life, which will help me greatly in my future study and career development.

The second benefit is to carry out academic research properly. Eight months ago, I know little about research methods. After I get enrolled in this project, firstly I should carry out a background survey, and decide the research topic. Information searching and selection are also very important, such as how to choose the key word and get the main information contained in a journal paper. Citation is another key aspect in the research ethics. Newton said that “if I have seen farther than others it is because I was standing on the shoulders of giants”. To carry out academic research, we have to respect the previous work of the “giants”. Without correct and proper citation, our research may become plagiarism.
The last but not least gain is time management ability. The education mode for taught students is attending class and finishing home work. Therefore, I lack of sufficient environment to practice and take charge of an independent project. This program offers me the opportunity to conduct the project by myself. During the last eight months, I have to control and arrange the time-slot, set up deadlines for different phases. Besides, I have to make balance of this project and my other study; group discussion with other 3 classmates and my individual study on this project should be managed well too.

All in all, the MBA project is the unique experience for me. My learning skill on new subject has been improved to a great extent. It can cultivate my right attitude towards academic research and realize self-worth fulfillment.
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